

# Fungal Involvement in Bio Weathering of Historical Monument with Reference to Gopinath Temple at Gopeshwar Town, Chamoli, Uttarakhand, India

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**Abstract:** *Fungi are complex communities of microorganisms that damage historic monuments. The present study was made to examine the diversity of fungi associated with deteriorated monument sites. In the present investigation, 10 samples were collected from various portions of deteriorating sites of Gopinath temple at Gopeshwar Town of Chamoli district, Uttarakhand. Five fungal species isolated from deteriorated monument sites are reported in this paper. The most frequent isolated fungal species from the historic monument sites are Aspergillus niger. Present biological and mycological investigations focused on bio-deterioration of said monument by various fungal species.*

**Keywords:** Bio-deterioration, monument, fungi, stone, hyphae, mycelium, ruins, cultural media, heritage, cultural property

## 1. Introduction

### 1.1 History of Gopinath Temples

Gopinath Temple is an ancient Hindu temple dedicated to Shiva in Gopeshwar, Chamoli District, Uttarakhand, India. It is situated in Gopeshwar village now part of Gopeshwar town. The temple stands out in its architectural proficiency; it is topped by a magnificent dome and the 30 sq ft (2.8 m<sup>2</sup>) sanctum sanctorum, which is accessible by 24 doors. The remains of broken idols found around the temple testify the existence of several more temples in ancient times. There is a trident, in the courtyard of the temple, about 5 m high, made of eight different metals, which dates back to the 12th century. It boasts the inscriptions attributed to Ashokchalla, the king of Nepal who reigned in the 13th century. Four short inscriptions written in Devanagari, which dates back to a later period, are yet to be deciphered, barring one. Legend is that the trident got fixed in this spot, when Lord Shiva threw it at Lord Kama to kill him. The metal of the trident is not weathered by the elements and this is a wonder. The legend goes that the trident belonged to Shiva who threw it at Kamdeva (The God of Love) to kill him and it got fixed in this spot. It is believed that while brute force cannot move this Trident, the slightest touch by a true devotee can cause a tremor in it. The metal of the trident does not appear to have become weathered by the elements over the century<sup>1</sup>.



Figure 1: Front view of Gopinath temple

### 1.2 Causes of deterioration of monuments

Sandstone surfaces of monument are continuously affected by physical, chemical and biological agents. Among biological agents, microorganisms are responsible for the destruction of cultural property<sup>2-4</sup>. They can cause damage on the stone surface such as formation of bio-films, chemical reactions with the substrate, physical penetration into the substrate as well as pigment production. Numerous studies have dealt with establishing the role of biological agents in the stone deterioration<sup>5-6</sup>. During recent decades there has been a growing concern about deterioration of historic buildings. Along with chemical and physical factors, microbial growth plays an important role in this process<sup>7</sup>.

Microbial colonization of stones depends on environmental factors such as water availability, pH, climatic exposure, nutrient sources, and petrologic parameters such as mineral composition, type of cement, as well as the porosity and permeability of rock material. The stone ecosystem is subject to harsh environmental changes, especially due to temperature and moisture, exerting extreme selective pressure on any developing microbial community<sup>8-9</sup>. All fungi need some organic source for their growth, which is provided by metabolites of phototrophic organisms or by airborne deposition. It has been shown that very low nutrient requirements of some rock inhabiting fungi may be fulfilled by remains of polluted air and rain or animal remains and secretion<sup>10</sup>.

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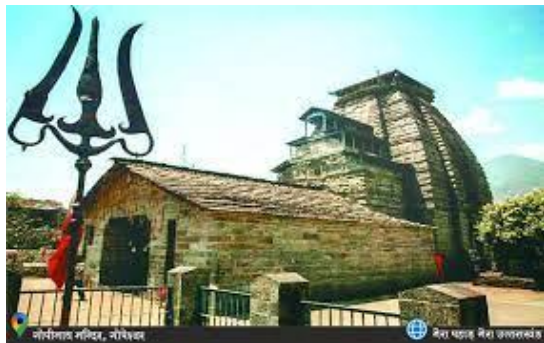


Figure 2: Lateral view of Goopinath temple

1.3 Conservation issue

The Gopinath temple is built of sand stone, which is porous in nature. The surface deposits seem to be very old due to the formation of secondary dull green pale white lichens, which are present all over the stone surface. Due to these growths of microbes, the aesthetic beauty of the temple is seriously affected (Fig:1-3). From a scientific point of view these growth of microbes are very harmful for the health of the stone surface, because these micro organisms secrete an acid that dissolves the sand stone<sup>11</sup>.



Figure 3: Showing micro-organism growth on the monuments

2. Materials and Methods

2.1 Sampling and Isolation of Fungi

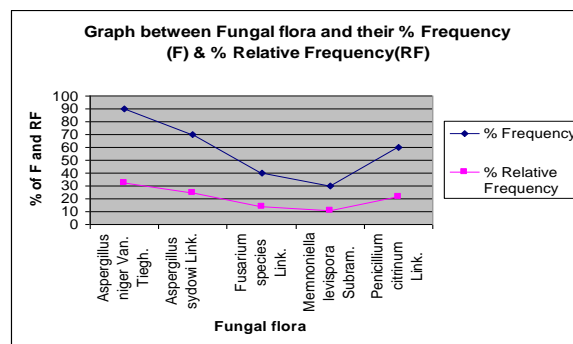
A total of 10 samples were collected from various places of monument and were brought to the laboratory under aseptic conditions. The isolation of micro-organisms was done by culturing the samples and by direct incubation of samples in moist chamber. The purified fungal cultures were identified (table) by using mycological techniques and were compared with the available authentic literature, reviews and mycological manuals<sup>9-10</sup>.

2.2 Calculations

Various myco-ecological characters have been calculated using the following formulae:

$$\% \text{ of Frequency (F)} = \frac{\text{Number of samples in which specific organism occurred}}{\text{Total number of samples examined}} \times 100$$

$$\% \text{ of Relative Frequency (RF)} = \frac{\text{Frequency of an individual species}}{\text{Frequencies of all species}} \times 100$$



3. Result and Discussion

The mentioned fungal species are typically soil fungi, which is in accordance with the results of ref<sup>9</sup>. who noted a considerable number of the same genus and species. The identified micro fungi cause discoloration as well as mechanical exfoliation of stone material that was analyzed through mechanical hyphae penetration and production of different pigments and organic acids. Refs<sup>9</sup> reported that a large number of fungi have great biochemical decay potential. Recently, it has been apparent that the ability of fungi to interact with minerals, metals, metalloids and organic compounds through biomechanical and biochemical processes, makes them ideally suited as biological weathering agents of rock and building stone. Biological and mycological investigations are a very important part of good conservation and cannot be ignored in the modern conservation concept, which includes close collaboration between art and science. This collaboration is the comparative study of the role of microbial colonization on the degradation of historic monuments<sup>10</sup>.

4. Conclusion

Cultural heritage is made up of a variety of material produced by nature and used by man. Cultural heritage objects are subjected to damage by fungi. The results of this study suggest that these fungi should not be ignored for their potential role in nutrient cycling by bio-deterioration of monuments. The possible outcome of this study is that valuable information about the diversity of fungi involved in the deterioration on monuments will be obtained.

Acknowledgement

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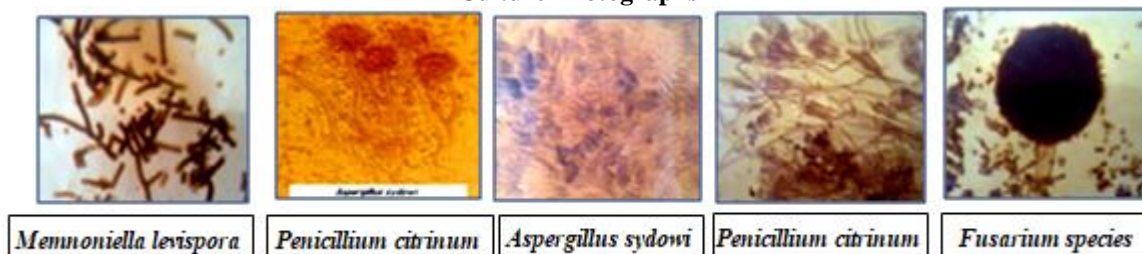
Table: Observation Table

Isolated Fungal Organism	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	S <sub>4</sub>	S <sub>5</sub>	S <sub>6</sub>	S <sub>7</sub>	S <sub>8</sub>	S <sub>9</sub>	S <sub>10</sub>	F%	RF%
<i>Aspergillus niger</i> Van. Tiegh.	+	+	-	+	+	+	+	+	+	+	90	31.03
<i>Aspergillus sydowi</i> Link.	-	+	+	+	+	-	+	+	-	+	70	24.13
<i>Fusarium species</i> Link.	+	-	-	+	-	-	-	+	+	-	40	13.79
<i>Memnoniella levispora</i> Subram.	-	+	+	-	-	-	+	-	-	-	30	10.34
<i>Penicillium citrinum</i> Link.	+	+	+	-	-	+	-	+	-	+	60	20.68
<b>Total</b>											<b>290</b>	<b>99.97</b>

Culture Plates



Culture Photographs



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